

Atty. Dkt. No. 039153-0472 (G1177)

**REMARKS**

Applicants respectfully request reconsideration of the present application in view of the foregoing amendments and in view of the reasons that follow.

Claim 18 is currently being amended. No new matter is added.

This amendment adds, changes and/or deletes claims in this application. A detailed listing of all claims that are, or were, in the application, irrespective of whether the claims remain under examination in the application, is presented, with an appropriate defined status identifier.

After amending the claims as set forth above, claims 1-20 are now pending in this application.

In Paragraph 3 of the Office Action, the Examiner objected to claim 18. Applicants have amended claim 18 in accordance with the Examiner's comments. Accordingly, withdrawal of the objection to claim 18 is respectfully requested. No new matter is added.

In Paragraph 4 of the Office Action, claims 1-20 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Andricacos (U.S. Patent No. 6,268,291) in view of Farrar (U.S. Patent No. 6,426,289) and Liu et al. (U.S. Patent No. 6,015,749). The Examiner states:

Andricacos teaches forming a barrier material layer along lateral sidewalls and a bottom of a via, the via electrically connecting a first conductive layer and a second conductive layer (Fig. 2, 4B, 5B, 6, col. 8, lines 48-60, col. 10, lines 13-20, 35-40). Andricacos discloses implanting a metal into the barrier material layer, the implanted metal making the barrier material layer more resistant to copper diffusion (col. 5, lines 60-65, col. 6, lines 45-67, col. 8, lines 15-20, col. 10, lines 33-40, 48-55, 60-65). Andricacos shows the barrier layer being tantalum and implanting tin (Sn) (heavy metal) (col. 10, lines 52-55, 62-65).

Andricacos does not specifically show the specific thickness, energy, tilted angle, and does as claimed. However, Andricacos teaches implanting at various energies ranging from a few KeV to

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several hundred KeV (col. 11, lines 7-10). Andricacos also discloses that during the implantation the wafer can be rotated to achieve uniformity and the energy and dose can be adjusted (col. 4, lines 17-37). In addition, Farrar shows forming a barrier layer having a thickness of 5 to 40 Angstroms and implanting with an energy level between 0.125 KeV to 2.0 KeV (col. 4, lines 25-38).

Liu et al. teaches implanting with an implanted tilted angle (1 to 20 degrees) to prevent implant damage (col. 2, lines 38-41, col. 4, lines 15-25). Liu et al. shows a dose of about  $1 \times 10^{15}$  atoms/cm<sup>2</sup> (col. 4, lines 20-21).

Furthermore, "where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation." In re Aller, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Andricacos reference by including the thickness and energy taught by Farrar and the tilted angle and energy taught by Liu et al. in order to better control the implantation process and to prevent damage (Liu et al., col. 2, lines 38-41). The modification is proper because the claimed ranges are not critical to the invention.

In addition, Andricacos shows the implanted metal forms an intermetallic with the second conductive layer (copper) (col. 13, lines 5-10). Andricacos teaches providing a copper layer over an integrated circuit substrate, providing a barrier material layer at a bottom and sides of a via positioned over the copper layer, implanting a low dose metal species into the barrier material layer at an angle of zero degrees (Fig. 2, 4b, 6, col. 8, lines 48-65).

Applicants respectfully traverse the rejection. Andricacos, Liu and Farrar are referred to below as the cited art.

As discussed in the previous response, independent claims 1, 10 and 15 recite the use of a tilt angle implant. The tilt angle is recited as being between one and ten degrees to provide a metal into the barrier layer. Claim 1 recites:

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tilt implanting at an angle between one and ten degrees, a metal into the barrier material layer . . .

Claim 10 recites:

implanting at an angle between one and ten degrees, a metal into the barrier material layer . . .

Claim 15 recites:

tilt implanting a metal species at an angle between one and ten degrees, into the barrier layer.

Therefore, each independent claim recites tilt angle implanting metal into a barrier layer.

The advantage of using a tilt angle implant is discussed in the present application. For example, the present application states:

Referring now to Figure 6, barrier layer 440 can also receive an implant 600 at a tilted angle. The implant of tilt can be one to ten degrees with respect to bottom 444 and via section 430. Implant 60 can be metal, which upon implant with barrier layer 440 can make barrier layer 440 amorphous and more resistance to copper (Cu) diffusion. Due to the tilted angle, barrier layer 440 at side walls 448 of via section 420 are made amorphous and resistant to copper diffusion.

See present application, paragraph [0030]. The cited art does not show, describe or suggest a tilt angle implant of metal into the barrier layer.

The Examiner admits that Andricacos only shows a zero degree implant angle. Andricacos does not mention a tilt angle with respect to the bottom of the via. Similarly, Farrar does not appear to disclose a tilt angle implant. The Examiner is utilizing Liu to teach an angled implant. However, Liu does not disclose implanting a metal with a tilt angle into the barrier layer. Indeed, Liu only teaches the implanting a semiconductor into the copper seed layer 5A, a very different process. Nowhere in Liu is discussed the implanting of metal into barrier layer 4.

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Accordingly, one of ordinary skill in the art would follow the teachings of the combination of Andricacos, Farrar and Liu to use a tilt angle implant of semiconductor atoms into the copper seed layer rather than metal atoms into the barrier layer and not achieve the present invention. Accordingly, it is respectfully submitted that independent claim 1 and its dependent claims 2-9, independent claim 10 and its dependent claims 11-14, and independent claim 15 and its dependent claims 16-20 are patentable over the cited art.

Further, Applicants respectfully submit that the combination of Liu, Andricacos and Farrar is improper because there is no motivation to combine Liu with Andricacos and Farrar. The Examiner states that the motivation for combining Liu with Farrar is to prevent damage. However, this motivation does not apply to the present invention because Liu is concerned with damage to silicon or metal silicide when implanting the seed layer with semiconductor atoms. Therefore, there is no motivation to combine Liu with Andricacos and Farrar because none of these references recognize the advantages discussed in the present application related to implanting metal into the barrier layer at a tilt angle. Accordingly, claims 1-20 are patentable over Liu, Andricacos and Farrar because the combination is improper.

Applicants believe that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested.

The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 06-1447. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Commissioner is authorized to charge the unpaid amount to Deposit

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Account No. 06-1447. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicant hereby petitions for such extension under 37 C.F.R. § 1.136 and authorizes payment of any such extensions fees to Deposit Account No. 06-1447.

Respectfully submitted,

Date 6-10-04

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